State of CERES

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CERES-Libera Science Team Meeting, May 11-13, 2021
Virtual Meeting

CERES-Libera Science Team Meeting

- Review status of CERES Instruments and Data Products
- Status of Libera Project
- Invited Presentations Session. Each presentation is 45 min including time for questions.
- Contributed Science Reports. Each report is 20 min including time for questions.

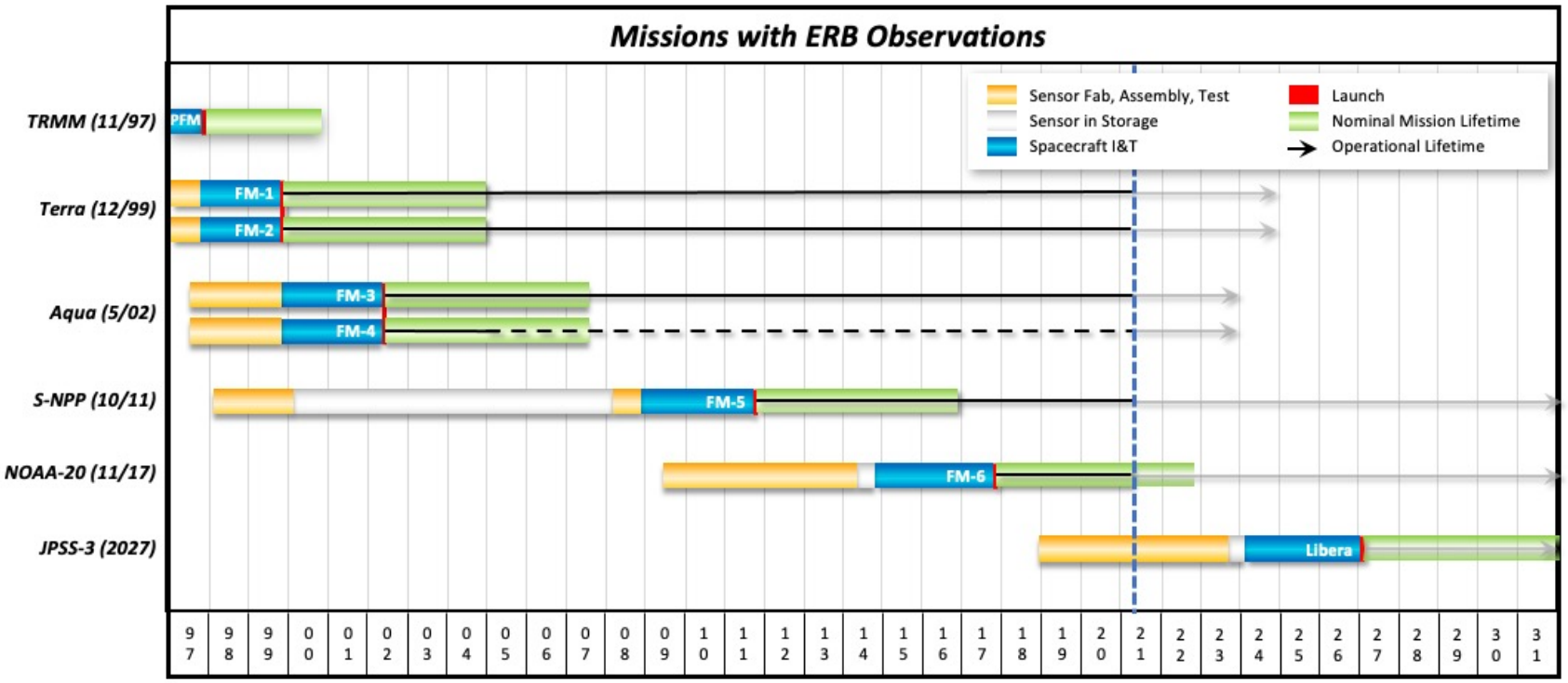
Please send an electronic copy of your presentation to Ed Kizer (edward.a.kizer@nasa.gov) at least one day prior to your presentation

CERES Technical Meeting

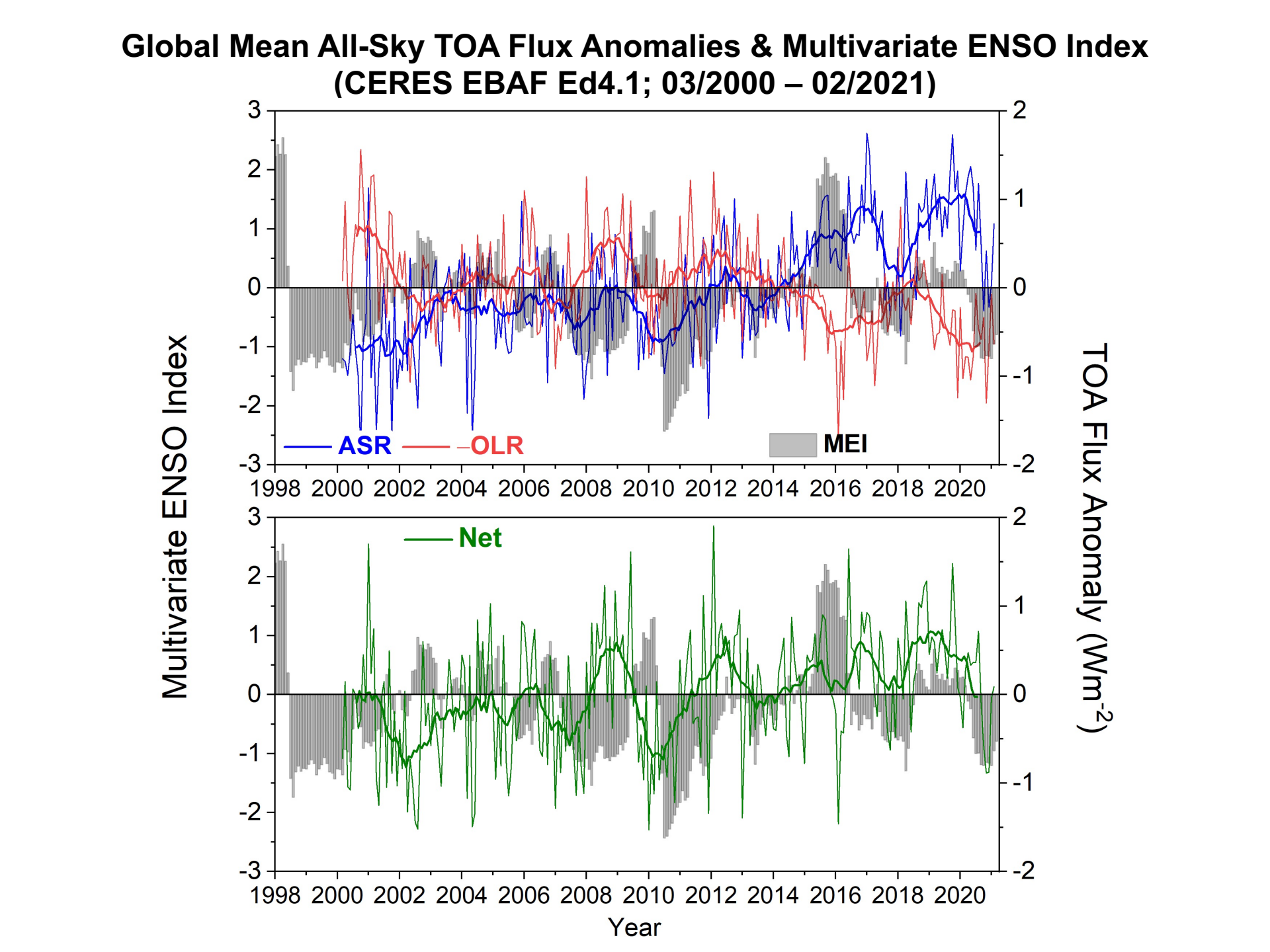
Review Status of CERES Instruments and Data Products:

- State of CERES
- CERES Terra, Aqua, S-NPP, NOAA-20 Instrument Calibration Update
- MODIS & VIIRS Cloud Algorithm & Validation Status
- ADM, SARB and TISA Working Group Reports
- FLASHFlux Update
- Data Management Team Update
- Outreach Update – **CLOUD OBSERVER SKILL TEST**! See Meetings page of CERES website for the Globe Observer App Directions

Flight Schedules

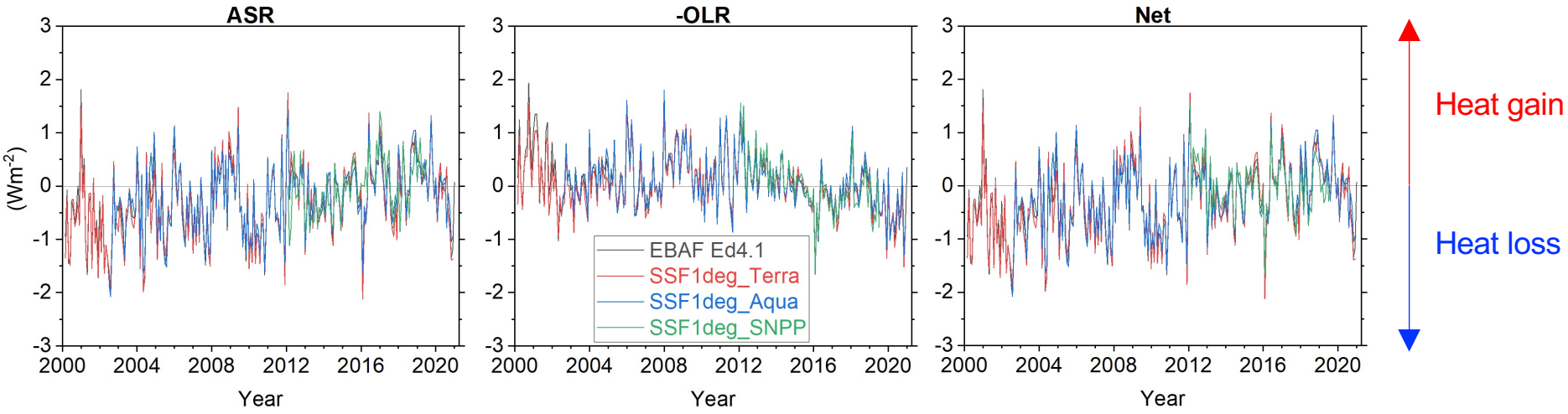


- Currently, 6 CERES instruments fly on 4 satellites: Terra (L1999), Aqua (L2002), SNPP(L2011), NOAA-20 (L2017)


Global Mean All-Sky TOA Flux Anomalies & Multivariate ENSO Index
(CERES EBAF Ed4.1; 03/2000 – 02/2021)
Multivariate ENSO Index
TOA Flux Anomaly (Wm-2)
ASR
OLR
MEI
Net
Year
1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020
3 2 1 0 -1 -2 -3

Global Mean All-Sky TOA Flux Anomalies

(Relative to Climatology for 02/2012-09/2019)

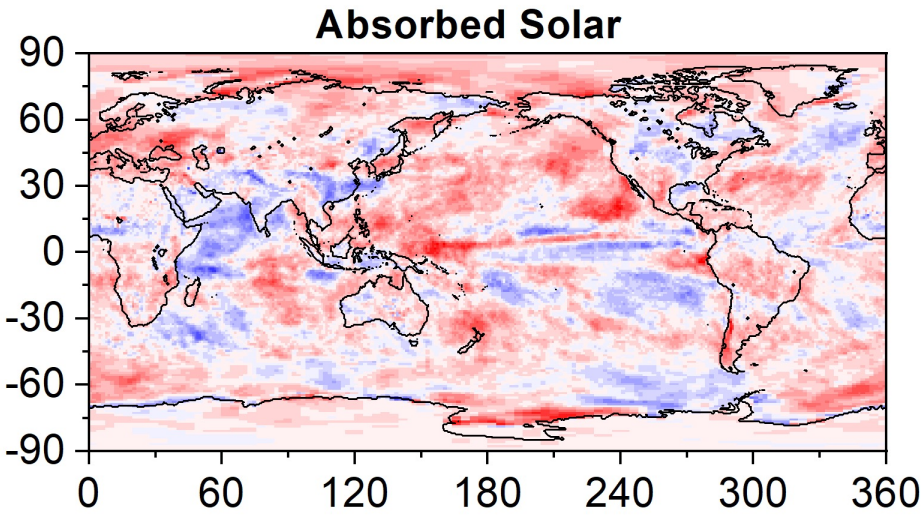


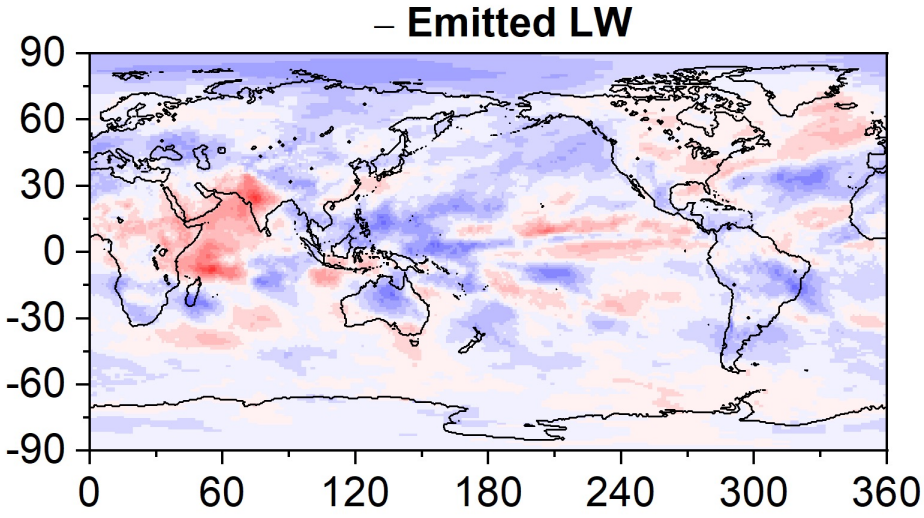
EBAF Trends (03/2000-02/2021)

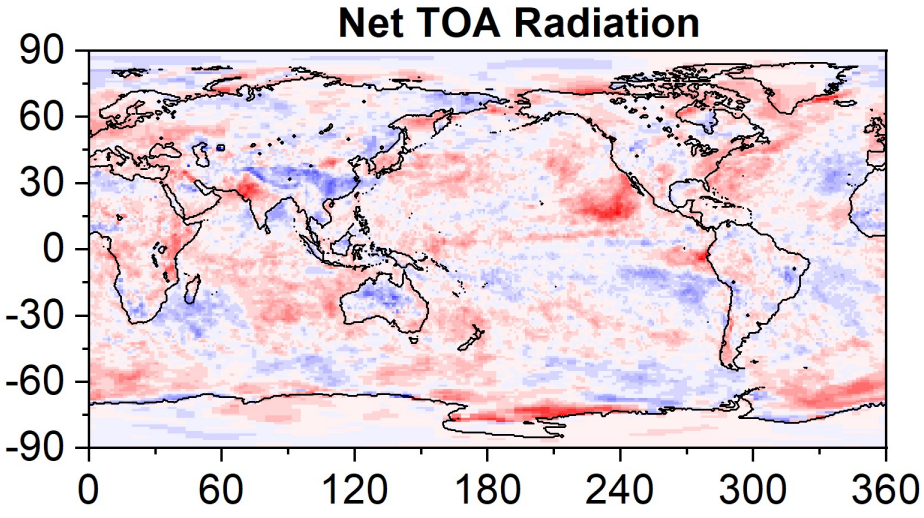
0.68 ± 0.12 Wm^{-2} per decade	-0.31 ± 0.12 Wm^{-2} per decade	0.37 ± 0.15 Wm^{-2} per decade

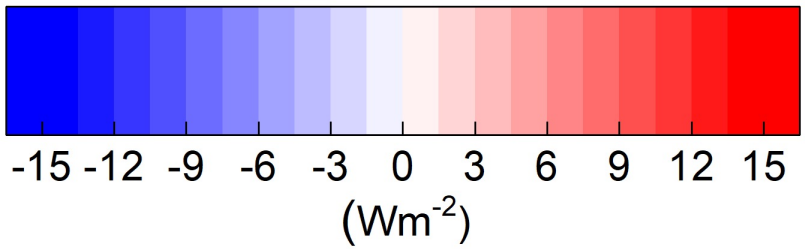
- RMS differences between monthly anomalies are < 0.2 Wm^{-2} for SW and LW; < 0.3 Wm^{-2} for net TOA flux.
- No significant drifts amongst the various records.

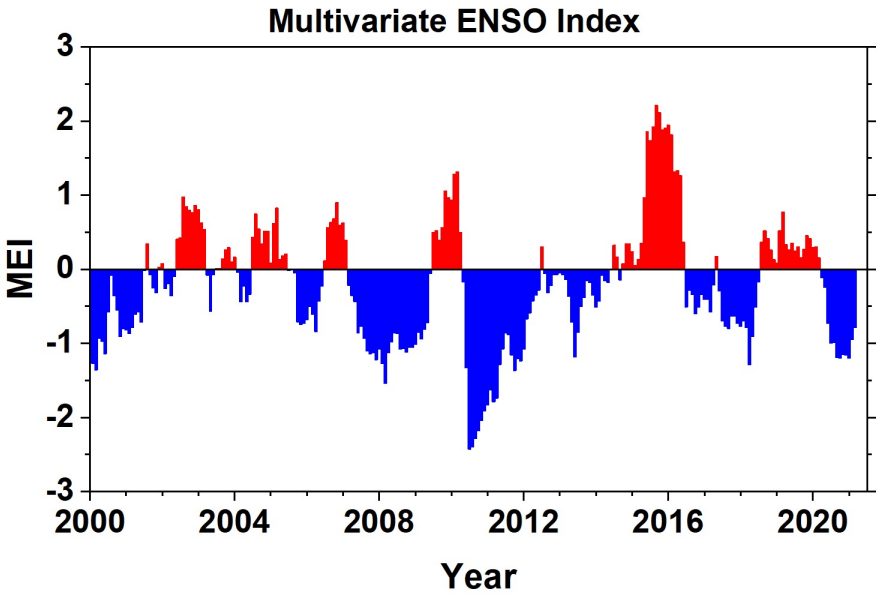
TOA Radiation Changes (03/2000 – 02/2021)



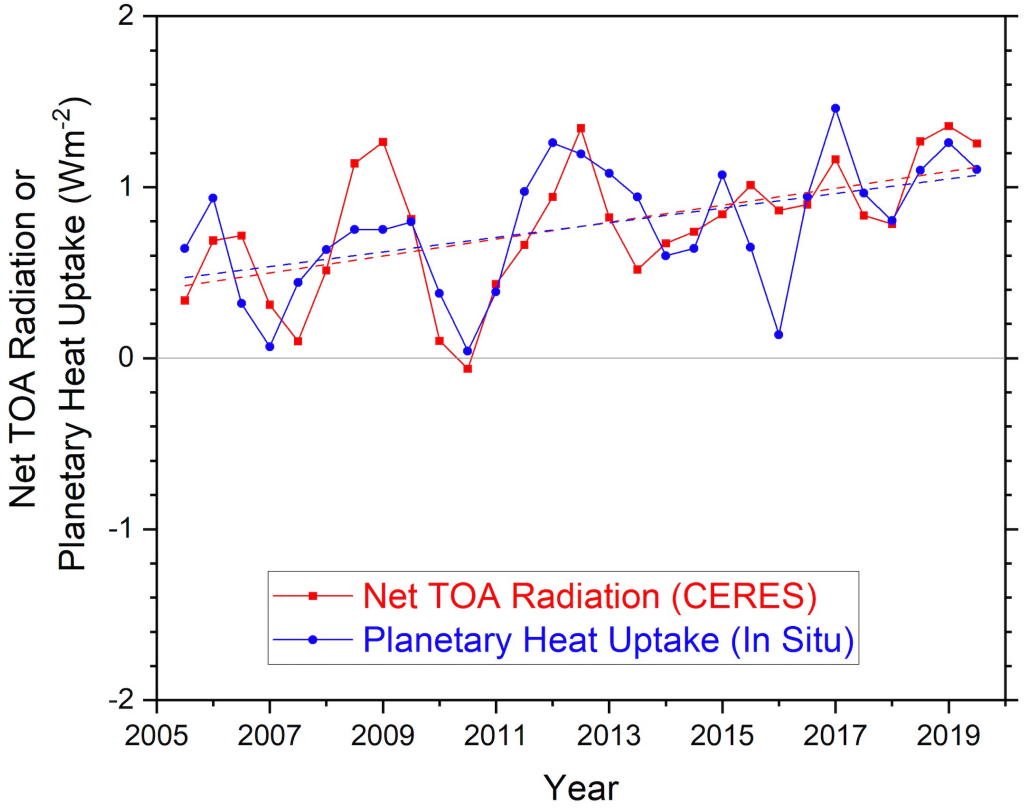








Annual Mean Net TOA Radiation & In-Situ Planetary Heat Uptake (07/2005-06/2019)



- CERES Net radiation & In-Situ PHU show consistent increasing trends with good agreement in year-to-year variability.

Trend and Uncertainty (Wm^{-2} per decade; 5%-95% CI)

Trend : 0.50 ± 0.47

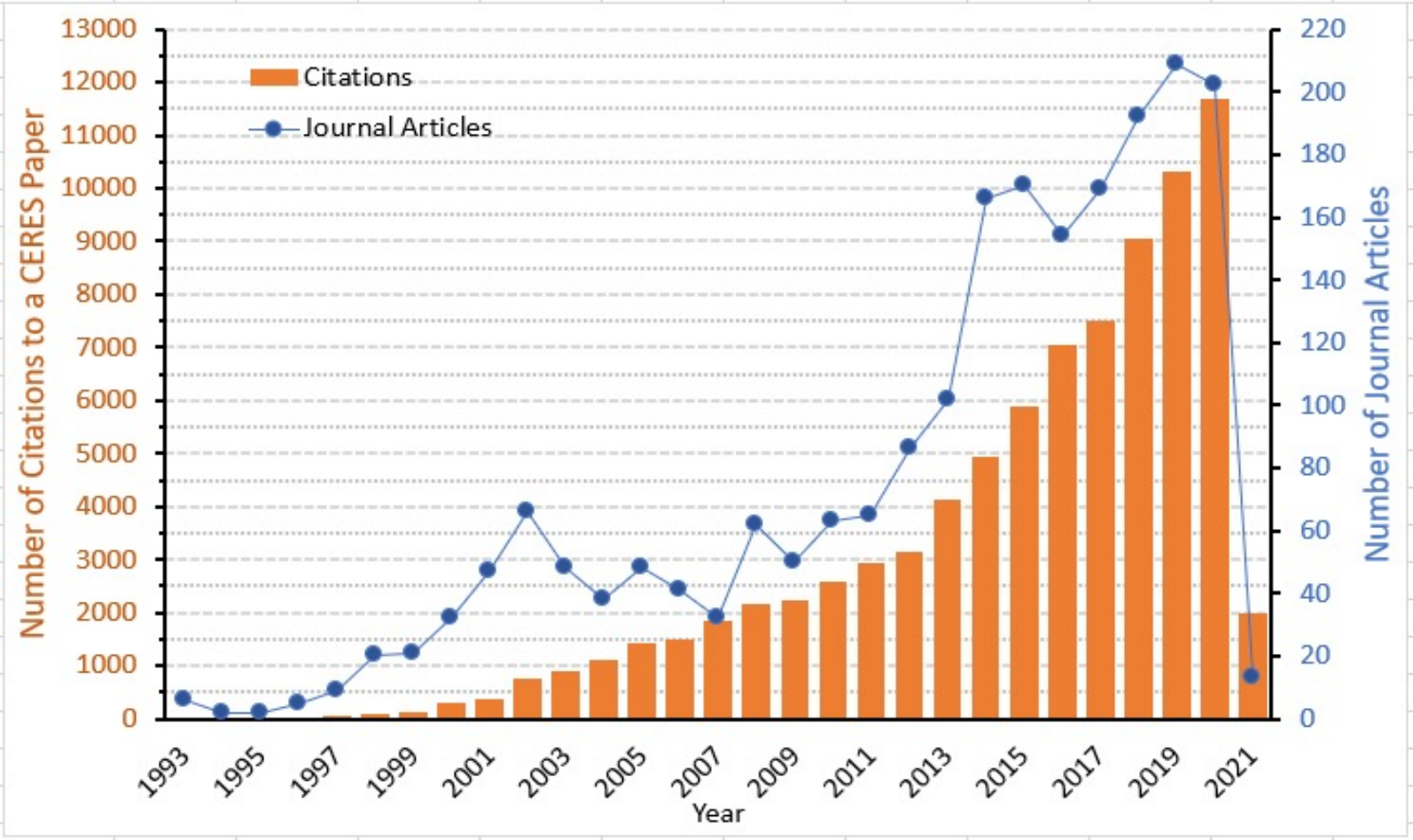
Trend Diff : 0.07 ± 0.29

R^2 = 0.49

Note: CERES and Argo+Altimeter are anchored to an EEI of 0.76±0.1 Wm^{-2} for 2005-2020 based upon in-situ data.

Loeb et al. (GRL; 2021)

CERES Journal Publications and Citation Counts
(For Papers Between 1993-2021; Updated March 25, 2021)



- Total number of peer-reviewed journal articles: 2,120
- Total number of citations to CERES papers: 84,166

(Compiled by Dennis Keyes)

Number of Unique Users by CERES Data Product

(through April 30, 2021)

Level	Product	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1b	BDS	9	14	19	14	11	13	14	10	12	19	5
2	SSF	77	138	223	247	253	278	327	235	251	229	75
	FLASH_SSF	8	15	23	30	61	41	68	101	92	97	39
	C3M	32	33	37	28	55	54	49	49	36	37	16
	ES8	20	18	31	16	21	15	15	10	8	8	0
	SSF-MISR	4	2	5	4	2	1	3	1	1	4	1
3 & 3b	EBAF									256	542	232
	EBAF-TOA	160	346	484	579	580	540	646	668	629	619	288
	EBAF-Surface		147	289	375	424	464	510	484	386	78	7
	SYN1deg	168	199	353	382	438	494	607	639	754	827	354
	SSF1deg	126	107	157	166	160	194	190	159	221	199	78
	CldTypHist	12	37	57	41	40	47	86	87	79	84	28
	FluxByCldTyp										44	26
	ES4	36	11	27	19	13	12	17	17	17	10	4
	ES9	12	5	13	9	5	5	8	6	6	3	1
	FLASH_TISA	18	20	17	15	15	36	52	65	81	127	48

FLASHFlux via POWER since last year: 69,500

Update of 2020 Terra and Aqua Senior Review

- Terra & Aqua proposals were submitted in March 2020.
- Panel meetings held on July 9, 2020.
- NASA HQ guidance letter sent to missions in October 2020.

Main Outcomes:

- Terra and Aqua both received a grade of “Excellent” in the Science category, “Very High” for Utility, “Low” for Technical Risk, and “Low” for Cost Risk.
- Requested over-guide funding was granted but only through end of FY2023 (September 2023).
- Mission extension beyond FY2023 will be revisited in the 2023 Senior Review (due March 2023).
- Terra and Aqua Projects are directed to conduct a special review of algorithms and data sets to quantitatively assess the anticipated impact of MLT drift on data product uncertainty, as well as the effectiveness of MLT drift mitigation strategies, for reconsideration in the 2023 Senior Review.
- Terra and Aqua Projects are directed to hold a Users’ Workshop to communicate quantitative changes in the datasets, to prepare users for the mission’s end-of-life, including evaluation of continuity products.

Changes to Terra and Aqua MLT

Terra:

- Completed all Inclination Adjust Maneuvers (IAMs) related to maintaining a 10:30 mean local time (MLT) equator crossing and 705 km orbit altitude.
- Began drifting to an earlier MLT in April 2021.
- In October 2022, will reach and exceed a 10:15 AM MLT crossing corresponding to a constellation exit with lower orbit altitude (694 km).
- MLT will continue to drift after this, reaching 9:00 AM around December 2025.

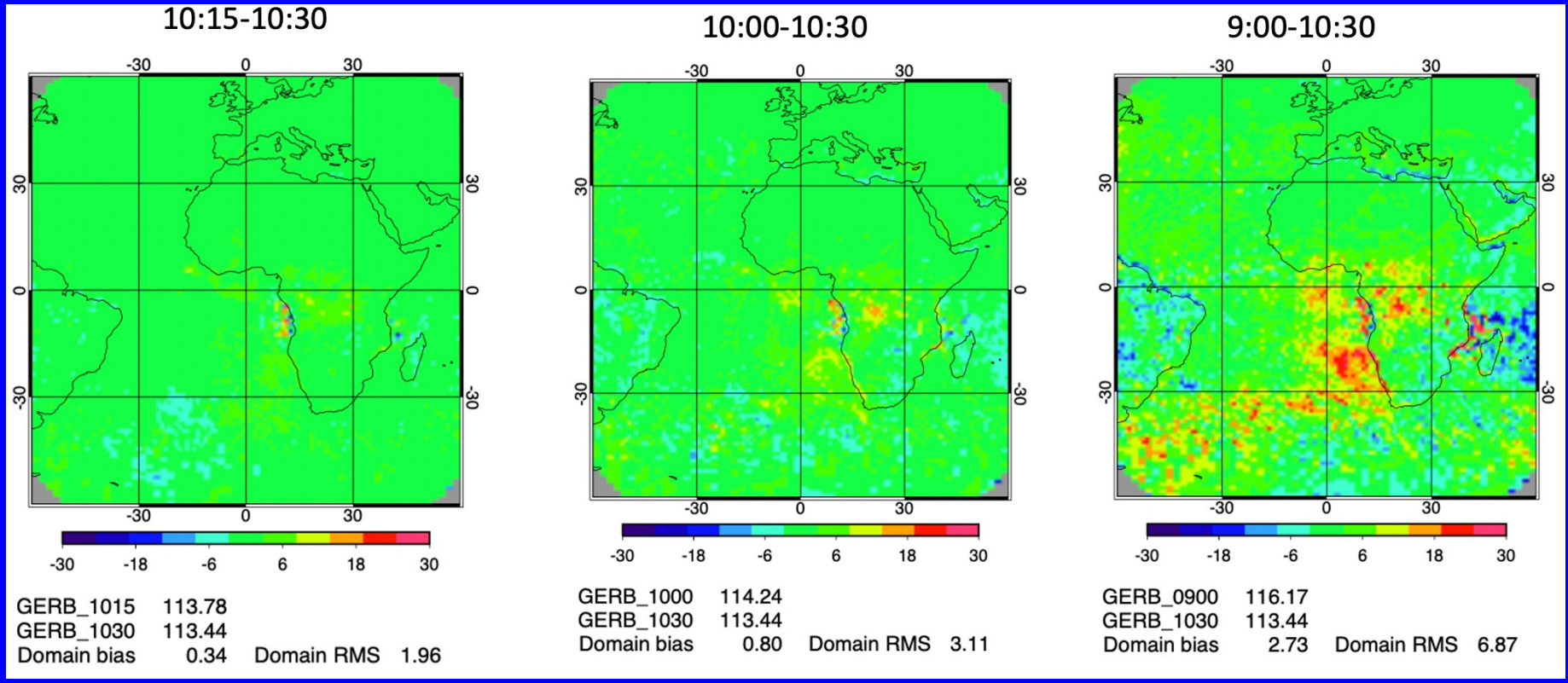
Aqua:

- Completed all IAMs related to maintaining a 13:30 MLT equator crossing and 705 km orbit altitude.
- Will begin drifting to a later MLT in January 2022. Will also exit A-Train constellation with lower orbit altitude (685 km).
- By mid-2022, will reach and exceed a 13:45 PM MLT crossing.
- MLT will continue to drift after this, reaching 15:30 PM around September 2025.

Question: At what point does a drift in MLT start impacting the quality of the CERES climate data record (e.g., EBAF)?

Impact of a Change in MLT on SW Reflected Solar Radiation

- Compare GERB SW TOA flux at 10:15 am, 10:00 am and 9:00 am vs 10:30 am
- Normalize each observation to a common 10:30 am solar geometry



- To avoid discontinuity in CERES record, MLT remain < 15 min of 10:30 am for Terra and 1:30 pm for Aqua.
- By mid-2022, need to reprocess CERES CDR with afternoon-only CERES instruments and transition from Aqua to NOAA-20.
- Will continue Terra-Only and Aqua-Only SSF1deg for remainder of these missions.

Selected Highlights & Accomplishments from PPBE 2023

- Requesting over-guide request to support RBSP participation in Libera pre-launch work.
- The CERES data products have been used in 202 journal publications by the science community.
- 23 journal publications describing CERES algorithms and validation results.
- 1,983 unique Climate Science Research users ordered CERES data products (17% increase).
- 69,500 unique Applied Science users ordered CERES data products via the POWER Web Portal.
- CERES team contributed 4 of the 20 papers published in the special issue in Remote Sensing: “Analysis of Decadal-Scale Continuous Data Products from Weather Satellite Platforms”.
- Made 67 production software deliveries to the ASDC to support:
  - Edition 4 Terra/Aqua, Edition 1 NPP and Ed1-CV NOAA-20 forward processing
  - Edition 2 NPP and Edition 1 NOAA-20 reprocessing and forward processing

Selected Highlights & Accomplishments from PPBE 2023 (Cont'd)

- Carried out special scans of the MOSAiC Expedition: Terra/FM2 was operated in Programmable Azimuth Plane (PAP) mode to target the Polarstern for 4-6 orbits daily between May 1 and Sep 10, 2020.
- Modified the instrument calibration algorithms to reduce the latency for Terra/Aqua Edition 4 product release by a factor of 1.5 (e.g., EBAF now has a 2-month latency).
- Ingested VIIRS-CrIS fusion IR radiance data into CERES Clouds processing to test continuity in derived cloud properties between MODIS and VIIRS.
- Delivered CERES-VIIRS NOAA20 Edition1B Clouds Code to improve continuity with MODIS Ed4 to mitigate MODIS data loss during the Aqua spacecraft anomaly in August 2020.
- Delivered FLASHFlux Version 4A production system.
- Validated, documented and publicly released the FluxByCloudType (FBCT) product. Submitted manuscript for publication describing the FBCT product.

Planning for Terra & Aqua Edition 5

Main Considerations:

1) GMAO improvements to their atmospheric reanalysis system.

   - CERES and GMAO hold WebEx meetings every 3 weeks to gauge progress and provide ongoing validation results for the latest GEOS FP or FPIT version.

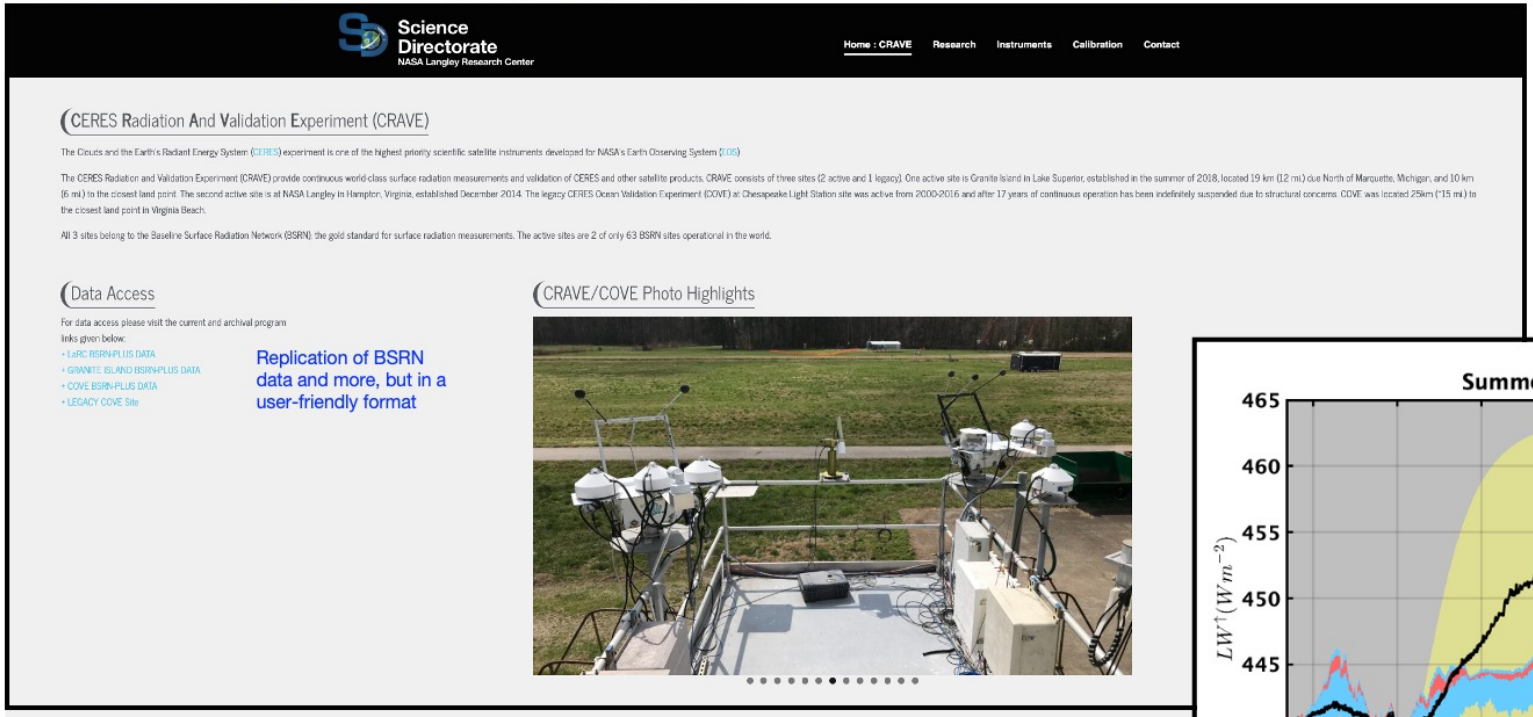
2) MODIS Collection 7 schedule.

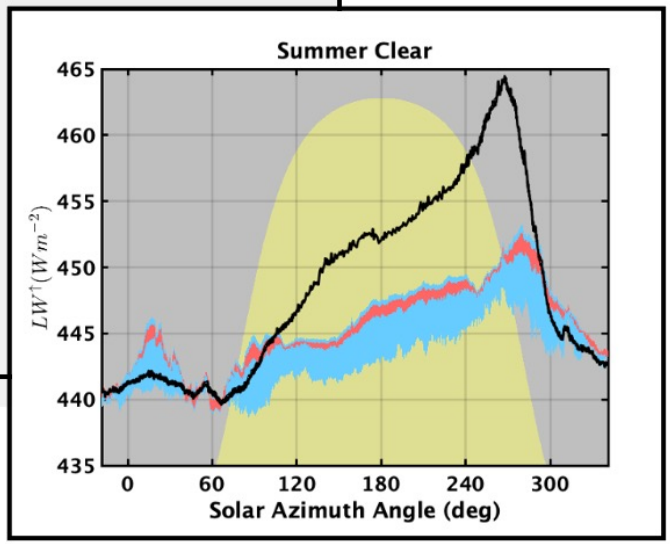
4) CERES production code improvements.

5) CERES algorithm improvements (particularly those enabling a seamless transition across satellite platforms).

CERES Radiation And Validation Experiment (CRAVE)

1. BSRN made it through the Lake Superior winter w/o longterm data loss (only ~2 weeks downtime)!
2. https://science.larc.nasa.gov/CRAVE/ (Webpage by Jay Madigan)





3. Dataset includes $LW^{\uparrow}$ flux correction, which is often 10+ W/m2

The significant size of the Chesapeake Lighthouse causes a large bias in the upwelling LW flux measurements wrt component fluxes that require correction (BSRN protocol requires accuracy better than 3 W/m2).

Component $LW^{\uparrow}$ flux:

$$LW^{\uparrow}_{f=0} = (1-\varepsilon_{air})[\varepsilon_w \sigma T_w^4 + (1-\varepsilon_{air})(1-\varepsilon_w)LW^{\downarrow}] + \varepsilon_{air}\sigma T_{air}^4,$$

Yellow shading: Solar elevation

Black line: $LW^{\uparrow}$ flux measurement

Blue shading: Component $LW^{\uparrow}$ flux, $\varepsilon_{air} = 0\text{-}1$

Red shading: Component $LW^{\uparrow}$ flux, $\varepsilon_{air} = 0.6\text{-}0.9$

Fall 2021 CERES Science Team Meeting

October 12-14, 2021 (Virtual)

CERES Science Team Meeting
TEST YOUR CLOUD OBSERVATION SKILLS!

1. Download the GLOBE Observer app to your mobile device
2. Select "Create an Account"
   a. Enter the email you wish to use and select your country affiliation
   b. Enter Referral Code: **GLIDSMU7** *(This will connect everyone to the same GLOBE Team)* and then select "Create Account"
   c. An email will be sent to this address with a password to be used on the next screen
   d. Enter the password
3. Select "GLOBE Clouds" to make a sky observation

Getting Started video: https://www.youtube.com/watch?v=cZM3PO5hoHU

GLOBE

This slide is available at:
CERES Homepage + News and Outreach + CERES STMs + CLOUD OBSERVER SKILL TEST